TECHNICAL BACKGROUND DOCUMENT FOR THE REPORT TO CONGRESS ON REMAINING WASTES FROM FOSSIL FUEL COMBUSTION:

WASTE CHARACTERIZATION

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1.0 INTRODUCTION

This document presents the data used to characterize fossil fuel combustion (FFC) wastes for the *Report to Congress on Remaining Wastes from Fossil Fuel Combustion*. The purpose of this document is to compile the data used for this purpose into one report. The Report to Congress itself further summarizes the data and discusses its ramifications.

This document is composed of two major sections: chemical characteristics (Section 2) and leachate characteristics (Section 3). The chemical characteristics section focuses on the total concentration of primary constituents of concern (e.g., metals) in FFC wastes. The leachate characteristics section focuses on the results of leaching analyses on FFC wastes. The primary analyses included are the toxicity characteristic leaching procedure (TCLP) and extraction procedure (EP) analysis, because these were the analyses used to characterize FFC waste leachate for use in the risk assessment portion of the Report to Congress. In a few cases, other analyses that are believed to be relevant to the characterization of FFC waste leachate (e.g., porewater data from surface impoundments managing coal combustion waste) are also presented. Physical characteristics (e.g., physical state, particle size) were described using standard industry texts and best professional judgment. They were not the subject of any detailed sampling efforts. Therefore, while these characteristics are summarized in the Report to Congress, they are not included in this data compilation.

Sections 2 and 3 each are subdivided into the following subsections: coal-fired utility waste as generated, comanaged coal-fired utility waste, oil combustion waste as generated, oil combustion waste as managed, and fluidized bed combustion (FBC) waste. Because EPA did not have any data specific to coal-fired non-utility combustion waste available, there are no sections corresponding to this sector. The specific sources of data used and methods used to summarize the data are described in the appropriate sections.

2.0 CHEMICAL CHARACTERISTICS

This section compiles and summarizes data used to describe the chemical characteristics and properties of remaining wastes from FFC. The tables presented here focus primarily on the total concentration of constituents of concern (e.g., metals). These data and their ramifications are discussed in greater detail in the Report to Congress.

2.1 COAL-FIRED UTILITY WASTES AS GENERATED

This section describes the chemical characteristics of large-volume coal combustion wastes (CCWs) (i.e., fly ash, bottom ash, boiler slag, and flue gas desulfurization [FGD] waste) and low-volume combustion wastes as individual waste streams. That is, it describes those wastes separately before they are mixed together and comanaged, as is the common practice at many coal-fired utilities. The two subsections below present data on large-volume and low-volume wastes, respectively.

2.1.1 Large-Volume Coal Combustion Wastes

Large-volume utility CCWs, managed alone, were the subject of, and characterized in detail in, the previous 1988 Report to Congress and the 1993 Regulatory Determination (58 FR 42466, 8/9/93). Therefore, a great deal of additional characterization data for these wastes has not been collected for the current Report to Congress. Instead, this section summarizes the characterization data originally collected for the 1988 Report to Congress and the 1993 Regulatory Determination. The original sources of these data are described in detail in those documents. Tables 2-1 through 2-4 present total concentration data for constituents of potential concern in coal-fired fly ash, bottom ash, boiler slag, and FGD waste, respectively.

Table 2-1. Coal-Fired Utility Large-Volume Wastes: Fly Ash Total Concentration Data (ppm)

Data Source	Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Tetra Tech[a] (Mech. Hopper Ash)	Arsenic	n/a	n/a	n/a	n/a	3.3	160	25.2
	Barium	n/a	n/a	n/a	n/a	52	1152	872
	Boron	n/a	n/a	n/a	n/a	205	714	258
	Cadmium	n/a	n/a	n/a	n/a	0.40	14.3	4.27
	Chromium	n/a	n/a	n/a	n/a	83.3	305	172
	Cobalt	n/a	n/a	n/a	n/a	6.22	76.9	48.3
	Copper	n/a	n/a	n/a	n/a	42.0	326	130
	Fluorine	n/a	n/a	n/a	n/a	2.50	83.3	41.8
	Lead	n/a	n/a	n/a	n/a	5.2	101	13.0
	Manganese	n/a	n/a	n/a	n/a	123	430	191
	Mercury	n/a	n/a	n/a	n/a	0.008	3.00	0.073
	Selenium	n/a	n/a	n/a	n/a	0.13	11.8	5.52
	Silver	n/a	n/a	n/a	n/a	0.08	4.0	0.70
	Strontium	n/a	n/a	n/a	n/a	396	2430	931
	Vanadium	n/a	n/a	n/a	n/a	100	377	251
	Zinc	n/a	n/a	n/a	n/a	56.7	215	155
Tetra Tech[b] (Fine Fly Ash)	Arsenic	n/a	n/a	n/a	n/a	2.3	279	56.7
	Barium	n/a	n/a	n/a	n/a	110	5400	991
	Boron	n/a	n/a	n/a	n/a	10.0	1300	371
	Cadmium	n/a	n/a	n/a	n/a	0.10	18.0	1.60
	Chromium	n/a	n/a	n/a	n/a	3.6	437	136
	Cobalt	n/a	n/a	n/a	n/a	4.90	79.0	35.9
	Copper	n/a	n/a	n/a	n/a	33.0	349	116
	Fluorine	n/a	n/a	n/a	n/a	0.40	320	29.0
	Lead	n/a	n/a	n/a	n/a	3.10	252	66.5
	Manganese	n/a	n/a	n/a	n/a	24.5	750	250
	Mercury	n/a	n/a	n/a	n/a	0.005	2.50	0.10
	Selenium	n/a	n/a	n/a	n/a	0.60	19.0	9.97
	Silver	n/a	n/a	n/a	n/a	0.04	8.0	0.501
	Strontium	n/a	n/a	n/a	n/a	30.0	3855	775
	Vanadium	n/a	n/a	n/a	n/a	11.9	570	248

Table 2-1. Coal-Fired Utility Large-Volume Wastes: Fly Ash Total Concentration Data (ppm)

Data Source	Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
	Zinc	n/a	n/a	n/a	n/a	14.0	2,300	210

Table 2-1. Coal-Fired Utility Large-Volume Wastes: Fly Ash Total Concentration Data (ppm) (continued)

Data Source	Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
1993 Data[c]	Antimony	46	35	n/a	10.5	0.2	205	4.6
	Arsenic	81	3	n/a	76.4	0.0003	391.0	43.4
	Barium	74	3	n/a	1589	0.02	10850	806.5
	Beryllium	12	0	n/a	201.8	0.200	2105	5.0
	Boron	27	0	n/a	469.5	2.98	2050	311
	Cadmium	66	41	n/a	6.1	0.0100	76.0	3.4
	Chromium VI	83	8	n/a	129	0.19	651	90
	Copper	78	1	n/a	123	0.20	655	112
	Lead	76	2	n/a	67.0	0.02	273	56.8
	Mercury	27	7	n/a	4.3	0.013	49.5	0.1
	Nickel	71	0	n/a	117.5	0.1	1270	77.6
	Selenium	81	16	n/a	8.7	0.0003	49.5	7.7
	Silver	62	42	n/a	3.7	0.01	49.5	3.2
	Thallium	11	4	n/a	19.2	0.15	85.0	9.0
	Vanadium	61	5	n/a	397	43.5	5015	252
	Zinc	79	0	n/a	286.5	0.28	2200	148

[a] Mechanical hopper fly ash data from Tetra Tech (1983) and presented in the 1988 Report to Congress
[b] Fine fly ash data from Tetra Tech (1983) and presented in the 1988 Report to Congress
[c] Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit
n/a = data not available

Table 2-2. Coal-Fired Utility Large-Volume Wastes: Bottom Ash Total Concentration Data (ppm)

Data Source	Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Tetra Tech[a]	Arsenic	n/a	n/a	n/a	n/a	0.50	168	4.45
	Barium	n/a	n/a	n/a	n/a	300	5789	1600
	Boron	n/a	n/a	n/a	n/a	41.9	513	161
	Cadmium	n/a	n/a	n/a	n/a	0.1	4.7	0.86
	Chromium	n/a	n/a	n/a	n/a	3.4	350	120
	Cobalt	n/a	n/a	n/a	n/a	7.1	60.4	24
	Copper	n/a	n/a	n/a	n/a	3.7	250	68.1
	Fluorine	n/a	n/a	n/a	n/a	2.5	104	50.0
	Lead	n/a	n/a	n/a	n/a	0.4	90.6	7.1
	Manganese	n/a	n/a	n/a	n/a	56.7	769	297
	Mercury	n/a	n/a	n/a	n/a	0.005	4.2	0.023
	Selenium	n/a	n/a	n/a	n/a	0.08	14	0.601
	Silver	n/a	n/a	n/a	n/a	0.1	0.51	0.20
	Strontium	n/a	n/a	n/a	n/a	170	1800	800
	Vanadium	n/a	n/a	n/a	n/a	12.0	377	141
	Zinc	n/a	n/a	n/a	n/a	4.0	798	99.6
1993 Data[b]	Antimony	36	35	n/a	4.1	0.18	8.4	4.0
	Arsenic	48	5	n/a	7.7	0.80	36.5	4.7
	Barium	46	1	n/a	1526	24	9360	633
	Beryllium	2	0	n/a	2.2	1.4	2.9	2.2
	Boron	11	0	n/a	109.9	1.79	390	90.0
	Cadmium	48	38	n/a	2.7	0.050	5.5	3.1
	Chromium VI	48	4	n/a	411	3.41	4710	121.0
	Copper	48	0	n/a	61.4	2.39	146.3	61.1
	Lead	48	1	n/a	35.0	0.86	843.0	13.2
	Mercury	12	7	n/a	0.013	0.003	0.040	0.009
	Nickel	48	1	n/a	161.2	1.9	1267	79.6
	Selenium	48	31	n/a	1.1	0.0070	9.0	0.8
	Silver	40	33	n/a	3.0	0.06	7.1	3.0
	Thallium	1	0	n/a	---	2.0	2.0	---
	Vanadium	37	7	n/a	143.1	24.0	264	141
	Zinc	48	0	n/a	123.1	3.80	717	52.6

[a] Bottom and boiler slag (combined) data from Tetra Tech (1983) and presented in the 1988 Report to Congress

[b] Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

n/a = data not available

--- = too few data points to calculate statistics

Table 2-3. Coal-Fired Utility Large-Volume Wastes: Boiler Slag Total Concentration Data (ppm)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Antimony	3	0	n/a	0.7	0.25	1.0	0.8
Arsenic	15	7	n/a	23.0	0.01	254.0	4.5
Barium	15	7	n/a	698.7	6.19	1720	413
Beryllium	3	0	n/a	7.0	7.0	7.0	7.0
Boron	5	2	n/a	31.7	0.10	55.0	49.5
Cadmium	15	11	n/a	22.4	0.01	40.5	40.5
Chromium VI	15	1	n/a	592.1	1.43	5981	158
Copper	15	2	n/a	52.0	1.37	156	32.0
Lead	15	6	n/a	34.6	0.40	120.0	8.0
Mercury	15	15	n/a	5.1	0.016	9.5	9.5
Nickel	15	2	n/a	81.4	3.3	177	83.0
Selenium	14	8	n/a	4.8	0.010	14.0	4.5
Silver	15	13	n/a	22.2	0.01	74.0	37.0
Thallium	3	0	n/a	37.3	33.5	40.0	38.5
Vanadium	11	7	n/a	146.1	75.0	320.0	75.0
Zinc	15	2	n/a	79.2	4.43	530	35.8

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 2-4. Coal-Fired Utility Large-Volume Wastes: FGD Waste Total Concentration Data (ppm)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Antimony	31	25	n/a	15.8	3.65	90.0	6.0
Arsenic	36	5	n/a	53.6	0.0075	341.0	32.5
Barium	35	3	n/a	352.1	0.08	2280	162.5
Beryllium	14	7	n/a	27.7	0.900	49.5	29.3
Boron	18	11	n/a	144.8	5.00	633.0	60.0
Cadmium	36	22	n/a	19.2	0.005	81.9	3.9
Chromium VI	36	5	n/a	90.7	0.17	312.0	73.0
Copper	36	0	n/a	62.4	0.04	251.0	46.1
Lead	34	2	n/a	121.7	0.01	527.0	25.3
Mercury	15	7	n/a	5.2	0.073	39.0	4.8
Nickel	35	1	n/a	72.5	3.7	191.0	68.1
Selenium	34	9	n/a	12.1	0.0150	162.0	4.5
Silver	29	20	n/a	3.5	0.01	10.3	3.3
Thallium	6	6	n/a	9.0	9.0	9.0	9.0
Vanadium	33	16	n/a	104.9	0.01	302.0	65.0
Zinc	36	1	n/a	921.0	0.01	5070	90.9

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

2.1.2 Low-Volume Combustion Wastes

In the current Report to Congress, low-volume combustion wastes are of concern when they are comanaged with large-volume CCWs. Therefore, collection of characterization data has focused on mixtures of large-volume and low-volume wastes as comanaged in practice (see Section 2.2). Table 2-5 presents ranges of total concentration data for constituents of potential concern in several types of low-volume combustion wastes. These data were originally collected for the 1988 Report to Congress; sources of these data are described in detail there. In addition, because coal mill rejects (and particularly their pyrite component) have been identified as a waste of particular concern, this section includes recent data collected by the Electric Power Research Institute (EPRI) for coal mill rejects. Table 2-6 summarizes these data and data from the 1988 Report to Congress for coal mill rejects.

Table 2-5. Low-Volume Combustion Wastes: Total Concentration Data (mg/l)

Constituent	Boiler Blowdown	Coal Pile Runoff	Cooling Tower Blowdown	Demineralizer Regenerant	Boiler Fireside Cleaning Waste	Boiler Chemical Cleaning Waste (Alkaline)	Boiler Chemical Cleaning Waste (Acid)
Total Suspended Solids	2.7–31	8–2,500	0.2–220	0–300	119.1–3,823	5,580–6,720	8–2,375
Total Dissolved Solids	11–1,405	270–28,970	4.1–32,676	283–25,235	3,002–35,127	10–400	n/a
Aluminum	n/a	20–1,200	1,100–1,700	n/a	n/a	n/a	6.5–8.2
Arsenic	n/a	0.005–0.6	n/a	n/a	n/a	n/a	0.01–0.1
Barium	n/a	n/a	n/a	n/a	n/a	n/a	0.1–0.4
Beryllium	n/a	0.01–0.07	n/a	n/a	n/a	n/a	0–0.1
Boron	n/a	n/a	0.5–1	0–0.1	n/a	n/a	n/a
Cadmium	n/a	0.001–0.003	n/a	n/a	n/a	n/a	0.001–0.13
Chloride	n/a	3.6-481	5–16,300	0–20,500	0–18	n/a	n/a
Chromium (total)	0.02	0.005–16	0.00002–0.12	0–2,168	0.03–1	0.2–7.7	0.005–16.8
Chromium VI	0.005–0.009	n/a	n/a	n/a	n/a	n/a	n/a
Cobalt	n/a	0.025	n/a	n/a	n/a	n/a	n/a
Copper	0.02–2	0.01–6.1	0.00001–1.74	0–3.091	0.3	8–1,912	2.2–960
Iron	0.03–1.4	0.1–5,250	0.0001–1.16	0–2.25	30–900	180–1,0800	1,125–6,470
Lead	n/a	n/a	0.004	0.16–37.5	n/a	0.004–23	0.01–5.2
Magnesium	n/a	0–174	0.0001–1.58	0–0.753	190.3–11,949	n/a	5.7–8.8
Manganese	n/a	0.9–180	0.024–0.22	0–3.1	n/a	0.1–14.3	6.9–29
Mercury	n/a	0.0002–0.007	0.0015	0.00005	n/a	n/a	0–0.002
Nickel	0.03	0.1–4.5	0.00003–0.15	0–0.56	30	n/a	3–500
Selenium	n/a	0.001–0.03	n/a	n/a	n/a	n/a	0.002–0.004
Silver	n/a	n/a	n/a	n/a	n/a	n/a	0.02–0.2
Sulfate	n/a	130–20,000	7.2–20,658	4.5–9,947	299.4–11,949	n/a	1–10
Zinc	0.01–0.05	0.006–26	0.00002–3.0	0–4.5	2–28.7	3.1–390	0.9–840

n/a = data not available
Sources: Envirosphere, 1981; Radian, 1987

Table 2-6. Low-Volume Combustion Wastes: Mill Rejects Total Concentration Data (ppm)

Data Source	Constituent	Number of Samples	Number of Non-Detects	Mean	Minimum	Maximum	Median
Enviro-sphere[a] (Pyrites)	Arsenic	n/a	n/a	n/a	500	5,000	n/a
	Cobalt	n/a	n/a	n/a	100	5,000	n/a
	Copper	n/a	n/a	n/a	10	10,000	n/a
	Lead	n/a	n/a	n/a	200	1,000	n/a
	Manganese	n/a	n/a	n/a	10	5,000	n/a
	Nickel	n/a	n/a	n/a	10	1,000	n/a
	Selenium	n/a	n/a	n/a	10	100	n/a
	Silver	n/a	n/a	n/a	10	50	n/a
	Vanadium	n/a	n/a	n/a	100	200	n/a
	Zinc	n/a	n/a	n/a	500	10,000	n/a
EPRI[b]	Major Constituents (maximum concentration greater than approximately 1 percent)						
	Calcium	20	0	91,700	6700	267,000	51,900
	Iron	20	0	132,400	9500	357,300	130,600
	Magnesium	20	0	14,200	1800	60,300	7,700
	Manganese	20	0	8,500	100	146,100	600
	Potassium	20	3	6,100	50	19,100	4,600
	Trace Constituents						
	Arsenic	20	2	104	1.50	447	37
	Barium	20	0	370	48.0	1,070	293
	Cadmium	20	19	3.78	3.5	9	3.50
	Chromium	20	0	64.8	9	3,380[c]	58.0
	Copper	20	2	23.5	4.5	69	20
	Lead	20	14	18.4	4.5	121	4.5
	Mercury	20	0	0.35	0.04	0.88	0.32
	Nickel	20	0	48.3	9	464	25
	Selenium	20	9	11.1	2.5	50	7.5
	Silver	20	10	12.6	4.5	41	6.75
	Zinc	20	18	23.05	4.5	225	4.50

[a] Data from Envirosphere (1981) and presented in the 1988 Report to Congress; data are for pyrite portion of mill rejects
[b] Data from EPRI, 1997l; values below the detection limit were treated as one-half the detection limit
[c] Considered to be an outlier (not included in statistics)
n/a = data not available

2.2 COMANAGED COAL-FIRED UTILITY WASTES

This section describes the chemical characteristics of comanaged coal-fired utility wastes. That is, it describes mixtures of large-volume CCWs and low-volume combustion wastes after they have been placed together and comanaged, as is the common practice at many coal-fired utilities. Comanaged coal-fired utility waste characterization data are compiled from 16 reports, each detailing site investigations from the late 1980s to early 1997. They include 14 EPRI site investigations, plus 2 additional reports characterizing the comanagement of FGD sludge with low-volume wastes published by EPRI (1994a and 1994b). The 16 reports include characterization data for comanaged wastes as managed in both landfills and surface impoundments. Table 2-7 summarizes the data for landfills and Table 2-8 summarizes the data for surface impoundments.

In addition, data characterizing dioxins and furans in comanaged wastes are available from an EPRI (1998) study. This study analyzed samples from 11 disposal sites for 17 polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) that are currently considered to be of toxicological significance. Fifteen samples were taken, 2 of which were analyzed twice, for a total of 17 analyses. Table 2-9 summarizes these data.

Table 2-7. Coal-Fired Utility Comanaged Wastes: Total Concentration Data for Wastes Comanaged in Landfills (ppm)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	6	0	3	20	6.2	38	16
Barium	6	0	3	2,900	1,800	3,800	3200
Cadmium	6	6	3	Not calculated*			
Chromium	6	2	3	50	35	78	38
Copper	6	0	3	105	97	120	99
Lead	6	1	3	17	6.5	29	16
Nickel	6	0	3	51	33	65	54
Selenium	6	3	3	14	0.8	32	9.1
Silver	6	5	3	Not calculated*			
Vanadium	6	0	3	86	23	160	77
Zinc	6	3	3	84	35	160	53

* The constituent was not detected in any samples or detected in a small number of samples; therefore, meaningful statistical values cannot be calculated.
Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI Comanagement data. Includes wastes sampled within the landfills.

Table 2-8. Coal-Fired Utility Comanaged Wastes: Total Concentration Data for Wastes Comanaged in Surface Impoundments (ppm)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Antimony	26	24	7	Not calculated*			
Arsenic	45	9	15	40	6.7	150	18
Barium	45	6	15	1,600	150	8,400	510
Beryllium	11	0	3	8.4	0.88	16	8.3
Boron	15	6	5	190	0.03	420	140
Cadmium	45	36	15	6.0	0.20	24	5.4
Chromium	45	17	15	85	5.7	290	86
Cobalt	17	6	4	29	4.7	42	34
Copper	45	2	15	78	2.2	150	86
Lead	45	5	15	42	5.0	150	24
Nickel	45	6	15	68	1.5	160	71
Selenium	45	17	15	37	0.025	320	6.6
Silver	39	30	14	5.2	0.03	14	5.3
Thallium	11	1	3	27	10.6	48	23
Vanadium	45	21	15	120	20	350	60
Zinc	45	0	15	150	17	860	79

* The constituent was detected only in a small number of samples; meaningful statistical values cannot be calculated.
Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI Comanagement data. Includes wastes sampled from within the impoundments.

Table 2-9. Coal-Fired Utility Comanaged Wastes: PCDDs and PCDFs Concentrations in Coal Combustion Wastes (ng/kg, ppt)

Type of Analyte	Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
PCDDs	2,3,7,8-TCDD	17	17	11	0.17	0.05	0.4	0.15
	1,2,3,7,8-PeCDD	17	17	11	0.25	0.1	0.45	0.25
	1,2,3,4,7,8-HxCDD	17	17	11	0.35	0.1	0.75	0.3
	1,2,3,6,7,8-HxCDD	17	17	11	0.28	0.1	0.6	0.25
	1,2,3,7,8,9-HxCDD	17	16	11	0.30	0.1	0.65	0.25
	1,2,3,4,6,7,8-HpCDD	17	11	11	0.59	0.2	1.0	0.65
	OCDD	17	5	11	10.54	0.4	32.8	9.7
PCDFs	2,3,7,8-TCDF	17	14	11	0.19	0.05	0.41	0.15
	1,2,3,7,8-PeCDF	17	17	11	0.17	0.05	0.3	0.15
	2,3,4,7,8-PeCDF	17	17	11	0.17	0.05	0.3	0.15
	1,2,3,4,7,8-HxCDF	17	16	11	0.25	0.1	0.5	0.2
	1,2,3,6,7,8-HxCDF	17	17	11	0.18	0.05	0.4	0.15
	2,3,4,6,7,8-HxCDF	17	17	11	0.28	0.15	0.5	0.23
	1,2,3,7,8,9-HxCDF	17	17	11	0.24	0.1	0.5	0.25
	1,2,3,4,6,7,8-HpCDF	17	16	11	0.29	0.1	0.65	0.25
	1,2,3,4,7,8,9-HpCDF	17	17	11	0.35	0.1	0.85	0.3
	OCDF	17	15	11	0.59	0.15	1.55	0.45

Source: EPRI Sampling Data from EPRI, 1998 (Table A-3); summary statistics do not include the two blank or reference samples.

2.3 OIL COMBUSTION WASTES AS GENERATED

This section describes the chemical characteristics of oil combustion wastes as generated. That is, it describes fly ash and bottom ash before they are placed in a waste management unit (and possibly mixed together with each other or other combustion wastes). The source of these data is a database compiled by EPRI and submitted to EPA. Tables 2-10 and 2-11 present total concentration data for oil-fired fly ash and bottom ash, respectively. Data also are available from the same source for a small number of samples of washwater solids, composite ash, and other ash at oil-fired facilities. Because of the small number of data points, however, they are not summarized here.

Table 2-10. Oil Combustion Wastes: Fly Ash Total Concentration Data (ppm)							
Constituent	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Major Constituents (mean concentration greater than approximately 1 percent)							
Aluminum	17	0	4	30,789	18,000	45,605	29775
Calcium	17	4	5	11,428	7,100	25,700	7413
Iron	18	0	5	64,205	9,500	225,150	24300
Magnesium	18	0	5	53,253	7,870	131,337	25,660
Nickel	19	0	6	9,997	4,300	24,562	8,049
Potassium	11	4	3	9,543	3,400	21,228	4,000
Silicon	11	0	2	71,281	70,425	72,137	71,281
Sodium	17	0	5	12,143	8,214	17,400	11,000
Sulfate	2	0	2	59,450	28,900	90,000	59,450
Sulfur	10	0	2	60,948	18,067	103,830	60,948
Vanadium	34	0	10	48,816	22,528	110,647	45,386
Trace Constituents							
Antimony	3	1	1	442	442	442	442
Arsenic	18	0	6	82.0	34.0	198	64
Barium	18	1	6	907	330	2500	504
Boron	4	0	2	35.9	21.3	50.4	35.9
Cadmium	19	7	5	6.98	2.92	9.93	8.8
Cerium	3	0	1	180	180	180	180
Chloride	5	2	3	5,291	23	15,800	50
Chromium	24	0	8	1,016	138	4,000	374
Cobalt	1	0	1	233	233	233	233
Copper	12	0	5	587	270	920	655
Lead	21	0	6	515	288	1334	370
Manganese	8	0	3	331	120	698	175
Mercury	11	7	4	5.96	0.06	23.5	0.147
Phosphorus	3	1	1	5,447	5,447	5,447	5,447
Selenium	14	7	5	11.1	0.4	17.7	15.0
Silver	13	10	5	3.16	1.06	5.98	1.88
Titanium	6	0	2	3,876	3,105	4,646	3,876
Zinc	13	0	5	1,735	880	2,009	1,927

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

Table 2-11. Oil Combustion Wastes: Bottom Ash Total Concentration Data (ppm)							
Constituent	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Major Constituents (mean concentration greater than approximately one percent)							
Aluminum	16	0	6	67048	2000	150882	63993
Calcium	18	0	8	23091	6823	59000	22574
Iron	18	0	8	44377	4767	100871	45381
Magnesium	19	0	8	65148	14622	243774	42400
Nickel	17	0	9	13654	1950	44136	3730
Silicon	11	0	4	128823	42519	189360	141708
Sodium	13	0	7	18957	3500	32000	15400
Sulfate	3	0	3	14902	1974	35000	7732
Sulfur	1	0	1	56800	56800	56800	56800
Vanadium	47	0	13	55541	8749	200000	42359
Trace Constituents							
Antimony	1	0	1	1030	1030	1030	1030
Arsenic	14	4	5	23.5	3.6	52	19.4
Barium	15	1	5	594	248	820	662
Beryllium	1	0	1	67	67	67	67
Boron	2	1	2	33.5	12	55	33.5
Cadmium	14	7	3	3.12	0.50	4.77	4.10
Chloride	6	3	5	5844	5	28536	153
Chromium	27	2	4	205	33	675	55.3
Copper	17	0	5	789	154	2860	320
Lead	15	3	3	108	57	176	92
Manganese	3	0	3	327	200	520	260
Mercury	11	10	3	0.993	0.081	2.80	0.098
Selenium	11	9	3	6.07	2.16	10	6.05
Zinc	7	0	5	458	183	744	504

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

2.4 OIL COMBUSTION WASTES AS MANAGED

This section describes the chemical characteristics of oil combustion wastes as managed. Specifically, Table 2-12 presents total concentration data for constituents of potential concern in solids dredged from solids settling basins (SSBs) at oil-fired utilities. The source of these data is the same as that in the previous section.

Table 2-12. Oil Combustion Wastes: Solids Settling Basin Solids Total Concentration Data (ppm)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Antimony	5	2	1	66	66	66	66
Arsenic	62	7	17	210	6.28	1,650	16.05
Barium	60	12	15	317	7.18	980	210
Boron	1	0	1	160	160	160	160
Cadmium	50	21	10	5.5	0.2	21.7	3.6
Chromium	56	0	14	456	13	1,250	354
Cobalt	5	0	1	51	51	51	51
Copper	54	0	17	2,250	69	16,460	529
Fluoride	1	0	1	6.4	6.4	6.4	6.4
Lead	43	0	10	622	46	1,773	319
Manganese	6	0	5	868	72	2,600	665
Mercury	22	6	5	0.22	0.108	0.38	0.2
Nickel	69	1	17	9,410	2410	32,350	7150
Nitrate	1	0	1	24.4	24.4	24.4	24.4
Selenium	23	9	6	13.4	0.79	35.0	9.9
Silver	23	22	6	3.9	<0.10	9.7	2.7
Vanadium	85	0	19	31,580	880	69,670	27900
Zinc	48	0	17	830	74	4,010	437

Notes: Only constituents evaluated in the risk screening assessment are presented here. All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f.

2.5 FLUIDIZED BED COMBUSTION (FBC) WASTES

This section describes the chemical characteristics of FBC wastes. The data used here were submitted in response to a survey by the Council of Industrial Boiler Owners (CIBO) of all U.S. FBC facilities. Thirty-one respondents to the CIBO FBC survey, representing 37 percent of the total population of U.S. FBC facilities, provided a total of 211 total concentration samples. Thus, the FBC data presented here represent a large number of samples from a substantial fraction of the FBC population. Because the data were not identified as being from as-generated or as-managed samples, they are presented under one heading, rather than two headings as for conventional coal-fired and oil-fired combustion wastes. Tables 2-13 through 2-15 present data for FBC fly ash, bed ash, and combined ash, respectively.

Table 2-13. FBC Wastes: Fly Ash Total Concentration Data (ppm)							
Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Aluminum	40	0	12	42,700	20	88,900	42,300
Antimony	66	34	16	33.4	0.125	259	7.75
Arsenic	73	15	19	38.1	2.8	176	27.545
Barium	72	4	18	542	31.3	2690	348
Beryllium	39	15	10	3.31	1.08	11.5	2.23
Boron	60	15	11	366	0.025	2470	39.1
Cadmium	72	38	19	1.79	0.013	6.68	1.25
Chromium	76	1	19	46	5.17	97.1	44.8
Cobalt	47	7	13	22.3	2.5	79.8	19
Copper	71	12	17	40.5	2	99	41.1
Iron	44	0	13	31,700	22.2	76,500	25,300
Lead	75	25	19	30.3	1.03	105	25
Manganese	40	1	13	223	0.05	548	165
Mercury	73	27	18	7.86	0.00005	129	0.323
Molybdenum	67	14	19	13.9	2.35	48.6	6.25
Nickel	75	2	20	179	6.25	923	41.4
Potassium	43	13	10	4,570	1.13	10,200	3510
Selenium	69	27	19	19.5	0.47	166	8.36
Silver	64	40	18	2.35	0.05	11.6	1.03
Thallium	34	22	8	9.46	1.25	39	3.28
Vanadium	39	0	10	771	36.4	3,830	194
Zinc	73	1	18	53	24	143	38.5

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 2-14. FBC Wastes: Bed Ash Total Concentration Data (ppm)							
Constituent	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Aluminum	34	0	9	22,800	9	68,800	18,000
Antimony	58	37	13	40.1	0.125	361	10
Arsenic	62	16	14	25.1	2.5	80	14.6
Barium	68	5	15	190	7.3	453	184
Beryllium	38	14	10	3	0.5	8	1.21
Boron	52	18	8	79.1	0.025	304	14.1
Cadmium	61	40	14	1.79	0.0125	7.16	1.02
Chromium	68	0	15	36.4	4.1	86	37
Cobalt	47	10	12	16.9	1.4	75.8	11.3
Copper	65	15	14	17.5	1.65	37.1	13.8
Iron	33	0	8	11,000	6.2	19,300	11,100
Lead	67	30	15	18.9	0.848	58	12.5
Manganese	33	0	9	311	52.2	751	241
Mercury	54	46	12	1.43	0.00005	16.2	0.05
Molybdenum	52	15	11	20.8	6	63.4	14.7
Nickel	63	3	14	190	1	945	22
Potassium	41	22	7	177	1.3	8,980	584
Selenium	56	39	13	5.45	0.152	45	0.952
Silver	55	40	13	8.57	0.05	87.6	1
Thallium	29	23	6	7.63	0.5	25	3.03
Vanadium	37	0	8	987	12	5240	69
Zinc	65	2	14	64.7	17.4	399	34

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 2-15. FBC Wastes: Combined Ash Total Concentration Data (ppm)							
Constituent	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Aluminum	48	0	13	24,500	1,700	51,900	26,700
Antimony	45	28	15	14.3	0.065	62	7.25
Arsenic	60	7	16	25.1	1.4	77.2	23
Barium	57	3	14	258	39.2	690	181
Beryllium	12	3	6	2.97	0.148	9.5	2.19
Boron	45	3	13	149	1.25	1670	20.8
Cadmium	50	24	16	1.53	0.009	5.9	0.808
Chromium	58	0	16	43.7	12	181	36.2
Cobalt	30	4	12	5.6	0.6	18.7	4.56
Copper	56	0	16	40.1	1.9	192	29
Iron	48	0	13	13,120	850	27,600	10,700
Lead	57	6	16	23.2	0.45	67	19
Manganese	47	0	12	88.7	20	211	74.2
Mercury	57	8	16	0.431	0.0113	1.68	0.286
Molybdenum	50	14	14	9.65	0.125	41	8.07
Nickel	59	3	16	142	0.77	985	18.6
Potassium	26	0	12	3,550	2.82	9,160	4,220
Selenium	59	12	16	5.86	0.404	18	4.8
Silver	48	25	15	2.75	0.479	21.8	1.16
Thallium	8	4	6	5.56	0.09	12.5	5.15
Vanadium	11	0	5	144	26.3	5,000	440
Zinc	57	0	15	3,150	11	45,300	26

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

3.0 LEACHATE CHARACTERISTICS

This section compiles and summarizes data used to describe leachate from remaining wastes from FFC. For most waste types, this section includes results from toxicity characteristic leaching procedure (TCLP) and extraction procedure (EP) analyses. In a few cases, other analyses that are believed to be relevant to the characterization of FFC waste leachate (e.g., porewater data from surface impoundments managing coal combustion waste) are also presented. These data and their ramifications are discussed in greater detail in the Report to Congress.

3.1 COAL-FIRED UTILITY WASTES AS GENERATED

This section presents leaching analyses of large-volume CCWs and low-volume combustion wastes separately. That is, it describes the leaching characteristics of those wastes separately before they are mixed together and comanaged, as is the common practice at many coal-fired utilities. The two subsections below present data on large-volume and low-volume wastes, respectively.

3.1.1 Large-Volume Coal Combustion Wastes

Large-volume utility CCWs, managed alone, were the subject of, and characterized in detail in, the previous 1988 Report to Congress and the 1993 Regulatory Determination (58 FR 42466, 8/9/93). Therefore, a great deal of additional characterization data for these wastes has not been collected for the current Report to Congress. Instead, this section summarizes the leaching data originally collected for the 1988 Report to Congress and the 1993 Regulatory Determination. The original sources of these data are described in detail in those documents. Tables 3-1 through 3-8 present TCLP and EP data for constituents of potential concern in coal-fired fly ash, bottom ash, boiler slag, and FGD waste.

Table 3-1. Coal-Fired Utility Large-Volume Wastes: Fly Ash TCLP Data (mg/l)							
Analyte	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Arsenic	12	1	n/a	0.563	0.0039	2.68	0.066
Barium	12	0	n/a	0.382	0.113	0.910	0.289
Boron	8	0	n/a	4.02	0.120	17.4	0.933
Cadmium	12	5	n/a	0.078	0.0025	0.564	0.012
Chromium VI	12	3	n/a	0.556	0.010	4.64	0.203
Copper	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lead	12	7	n/a	0.455	0.005	2.94	0.025
Mercury	12	11	n/a	0.0048	0.0001	0.0495	0.0001
Selenium	12	4	n/a	0.037	0.0005	0.150	0.020
Silver	12	10	n/a	0.012	0.0025	0.0495	0.005
Vanadium	8	1	n/a	0.181	0.025	0.499	0.111
Zinc	8	0	n/a	20.0	0.020	103.0	0.285

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-2. Coal-Fired Utility Large-Volume Wastes: Fly Ash EP Toxicity Data (mg/l)

Data Source	Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Tetra Tech[a]	Arsenic	n/a	n/a	n/a	0.012	<0.004	1.46	n/a
	Barium	n/a	n/a	n/a	0.222	0.003	7.6	n/a
	Cadmium	n/a	n/a	n/a	0.0047	0.0001	1.4	n/a
	Chromium	n/a	n/a	n/a	0.036	0.001	0.68	n/a
	Lead	n/a	n/a	n/a	0.005	<0.0001	0.25	n/a
	Mercury	n/a	n/a	n/a	0.00042	<0.0001	0.007	n/a
	Selenium	n/a	n/a	n/a	0.01	<0.0001	0.17	n/a
	Silver	n/a	n/a	n/a	0.00064	<0.0001	0.20	n/a
ADL[b]	Arsenic	n/a	n/a	n/a	0.08	0.002	0.410	n/a
	Barium	n/a	n/a	n/a	0.34	0.1	0.7	n/a
	Cadmium	n/a	n/a	n/a	0.03	0.002	0.193	n/a
	Chromium VI	n/a	n/a	n/a	0.16	0.008	0.930	n/a
	Lead	n/a	n/a	n/a	0.01	0.003	0.036	n/a
	Mercury	n/a	n/a	n/a	<0.002	<0.002	---	n/a
	Selenium	n/a	n/a	n/a	0.05	0.002	0.340	n/a
	Silver	n/a	n/a	n/a	<0.001	<0.001	---	n/a
1993 Data[c]	Antimony	1	1	n/a	---	0.0495	0.0495	---
	Arsenic	76	19	n/a	0.393	0.001	16.4	0.038
	Barium	76	16	n/a	1.22	0.005	22.5	0.28
	Beryllium	5	3	n/a	0.0187	0.001	0.0495	0.002
	Boron	8	0	n/a	4.01	0.126	17.1	0.955
	Cadmium	78	21	n/a	0.0342	0.0003	0.548	0.01
	Chromium VI	78	25	n/a	0.249	0.001	8.37	0.0405
	Copper	8	1	n/a	0.888	0.0036	6.3	0.17
	Lead	77	39	n/a	0.0968	0.008	1.83	0.01
	Mercury	74	67	n/a	0.0023	0.00004	0.0495	0.0007
	Nickel	7	1	n/a	4.54	0.0495	29.4	0.45
	Selenium	77	18	n/a	0.0698	0.0005	0.376	0.027
	Silver	75	59	n/a	0.0161	0.0001	0.520	0.005
	Thallium	1	1	n/a	---	0.0495	0.0495	---
	Vanadium	14	3	n/a	4.47	0.005	26.9	0.665
	Zinc	16	1	n/a	10.82	0.009	111.0	0.372

[a] Data from Tetra Tech (1983) and presented in the 1988 Report to Congress; Tetra Tech's results are for coal ash in general
[b] Data from Arthur D. Little (1985) and presented in the 1988 Report to Congress
[c] Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit
n/a = data not available
--- = too few data points to calculate statistics

Table 3-3. Coal-Fired Utility Large-Volume Wastes: Bottom Ash TCLP Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	13	6	n/a	0.0058	0.0003	0.0328	0.002
Barium	13	0	n/a	0.500	0.087	1.61	0.290
Boron	10	0	n/a	0.308	0.033	1.59	0.163
Cadmium	13	13	n/a	0.0079	0.0005	0.0495	0.005
Chromium VI	13	11	n/a	0.0112	0.001	0.025	0.010
Copper	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lead	13	10	n/a	0.0199	0.002	0.080	0.005
Mercury	13	13	n/a	0.004	0.0001	0.0495	0.0001
Selenium	13	10	n/a	0.0051	0.0001	0.0495	0.0013
Silver	13	13	n/a	0.0088	0.0001	0.0495	0.0050
Vanadium	10	10	n/a	0.0135	0.0050	0.0495	0.0050
Zinc	10	5	n/a	0.065	0.010	0.176	0.015

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-4. Coal-Fired Utility Large-Volume Wastes: Bottom Ash EP Toxicity Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	30	17	n/a	0.013	0.0003	0.100	0.002
Barium	29	5	n/a	1.67	0.005	23.8	0.280
Boron	10	2	n/a	0.277	0.010	1.43	0.099
Cadmium	30	25	n/a	0.009	0.0001	0.050	0.005
Chromium VI	30	23	n/a	0.029	0.0004	0.250	0.010
Lead	30	21	n/a	0.049	0.0001	0.380	0.005
Mercury	29	25	n/a	0.003	0.00005	0.049	0.0003
Selenium	30	22	n/a	0.013	0.0001	0.100	0.002
Silver	29	25	n/a	0.014	0.0001	0.060	0.005
Vanadium	10	10	n/a	0.009	0.005	0.049	0.005
Zinc	10	4	n/a	0.042	0.007	0.092	0.030

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-5. Coal-Fired Utility Large-Volume Wastes: Boiler Slag TCLP Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	33	31	n/a	0.0087	0.001	0.118	0.002
Barium	33	7	n/a	0.490	0.015	5.60	0.260
Cadmium	33	26	n/a	0.0437	0.0000008	1.02	0.0018
Chromium VI	33	7	n/a	0.0093	0.0005	0.050	0.003
Copper	9	8	n/a	0.0811	0.015	0.400	0.050
Lead	33	20	n/a	0.260	0.0005	7.80	0.0025
Mercury	33	32	n/a	0.0306	0.0001	1.00	0.0002
Selenium	33	33	n/a	0.0036	0.0015	0.010	0.0025
Silver	33	32	n/a	0.0127	0.0001	0.050	0.0001
Vanadium	9	8	n/a	0.0111	0.010	0.020	0.010
Zinc	9	7	n/a	0.331	0.075	2.30	0.075

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-6. Coal-Fired Utility Large-Volume Wastes: Boiler Slag EP Toxicity Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	11	11	n/a	n/a	n/a	n/a	n/a
Barium	10	3	n/a	0.157	0.002	0.500	0.110
Cadmium	11	11	n/a	0.0009	0.0001	0.005	0.0003
Chromium VI	11	11	n/a	0.007	0.0005	0.020	0.005
Copper	2	2	n/a	0.100	0.100	0.100	0.100
Lead	11	11	n/a	0.009	0.0005	0.050	0.002
Mercury	9	9	n/a	n/a	n/a	n/a	n/a
Selenium	11	11	n/a	0.003	0.001	0.005	0.002
Silver	11	11	n/a	0.006	0.0001	0.025	0.001

n/a = data not available
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-7. Coal-Fired Utility Large-Volume Wastes: FGD Waste TCLP Data (mg/l)							
Analyte	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Arsenic	13	1	n/a	0.354	0.012	0.910	0.290
Barium	13	0	n/a	0.749	0.0009	3.30	0.532
Boron	1	0	n/a	---	12.4	12.4	---
Cadmium	13	4	n/a	0.0086	0.001	0.023	0.010
Chromium VI	13	0	n/a	0.146	0.031	0.300	0.120
Lead	13	3	n/a	0.139	0.001	0.360	0.120
Mercury	13	11	n/a	0.0003	0.0001	0.0015	0.0001
Selenium	13	1	n/a	0.291	0.002	0.910	0.280
Silver	13	3	n/a	0.0608	0.0045	0.160	0.060
Vanadium	1	0	n/a	---	0.229	0.229	---
Zinc	1	0	n/a	---	0.188	0.188	---

n/a = data not available
--- = too few data points to calculate statistics
Source: Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit

Table 3-8. Coal-Fired Utility Large-Volume Wastes: FGD Waste EP Toxicity Data (mg/l)

Data Source	Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
ADL[a]	Arsenic	n/a	n/a	n/a	0.20	0.002	0.065	n/a
	Barium	n/a	n/a	n/a	0.18	0.15	0.23	n/a
	Cadmium	n/a	n/a	n/a	0.01	0.002	0.020	n/a
	Chromium VI	n/a	n/a	n/a	0.02	0.011	0.026	n/a
	Lead	n/a	n/a	n/a	0.01	0.005	---	n/a
	Mercury	n/a	n/a	n/a	<0.002	<0.002	---	n/a
	Selenium	n/a	n/a	n/a	0.020	0.008	0.049	n/a
	Silver	n/a	n/a	n/a	<0.001	<0.001	---	n/a
1993 Data[b]	Antimony	10	6	n/a	0.129	0.010	0.570	0.030
	Arsenic	25	9	n/a	0.11	0.001	1.60	0.030
	Barium	23	5	n/a	0.448	0.075	2.80	0.230
	Beryllium	10	6	n/a	0.0013	0.0005	0.003	0.0005
	Boron	12	1	n/a	9.60	0.050	36.0	5.95
	Cadmium	25	17	n/a	0.066	0.0003	1.50	0.0025
	Chromium VI	23	8	n/a	0.075	0.0055	0.200	0.050
	Copper	11	1	n/a	0.040	0.005	0.120	0.022
	Lead	22	19	n/a	0.056	0.0005	0.680	0.009
	Mercury	23	18	n/a	0.002	0.00005	0.013	0.0003
	Nickel	11	3	n/a	0.043	0.0015	0.220	0.006
	Selenium	25	9	n/a	0.051	0.0015	0.230	0.040
	Silver	22	10	n/a	0.037	0.0005	0.200	0.0195
	Thallium	10	8	n/a	0.070	0.045	0.170	0.045
	Vanadium	11	0	n/a	0.126	0.030	0.270	0.074
	Zinc	12	2	n/a	0.040	0.0015	0.172	0.007

[a] Data from Arthur D. Little (1985) and presented in the 1988 Report to Congress
[b] Data from supporting documentation to the 1993 Regulatory Determination; values below the detection limit were treated as one-half the detection limit
n/a = data not available
--- = too few data points to calculate statistics

3.1.2 Low-Volume Combustion Wastes

In the current Report to Congress, low-volume combustion wastes are of concern when they are comanaged with large-volume CCWs. Therefore, collection of characterization data has focused on mixtures of large-volume and low-volume wastes as comanaged in practice (see Section 2.2). Tables 3-9 through 3-12 present EP analysis data for constituents of potential concern in several types of low-volume combustion wastes. These data were originally collected for the 1988 Report to Congress; sources of these data are described in detail in there. In addition, because coal mill rejects (and particularly their pyrite component) have been identified as a waste of particular concern, this section includes more recent TCLP and EP data collected by EPRI for coal mill rejects. Tables 3-13 and 3-14 summarize these data.

Table 3-9. Low-Volume Combustion Wastes: Boiler Chemical Cleaning Waste EP Toxicity Data (mg/l)

Data Source	Analyte	Number of Samples	Mean	Minimum	Maximum	Median
Radian, 1987[a]	Arsenic	10	0.112	0.002	0.36	n/a
	Barium	10	0.629	0.022	2.6	n/a
	Cadmium	10	0.181	0.002	0.21	n/a
	Chromium	10	8.467	0.02	35	n/a
	Lead	10	2.603	0.008	23	n/a
	Mercury	10	0.001	0.0002	0.0039	n/a
	Selenium	10	0.002	0.002	0.002	n/a
	Silver	10	0.065	0.001	0.2	n/a

Radian, 1985[b]	Analyte	Boiler Chemical Cleaning Waste (EDTA)	Boiler Chemical Cleaning Waste (Oxidizer)	Boiler Chemical Cleaning Waste (Hydrochloric Acid)
	Arsenic	0.006	<0.002	0.051
	Barium	0.76	0.67	0.91
	Cadmium	3.0	3.0	0.64
	Chromium	4.7	4.7	20.0
	Mercury	<0.0002	<0.0002	0.0042
	Lead	3.6	5.6	<0.002
	Selenium	<0.002	<0.002	<0.003
	Silver	<0.002	<0.002	0.007

[a] Data from Radian (1987) and presented in the 1988 Report to Congress
[b] Data from Radian (1985) and presented in the 1988 Report to Congress; data are for individual samples of three types of boiler chemical cleaning waste
n/a = data not available

Table 3-10. Low-Volume Combustion Wastes: Waterside Rinse EP Toxicity Data (mg/l)

Analyte	Number of Samples	Mean	Minimum	Maximum	Median
Arsenic	3	0.014	0.01	0.018	n/a
Barium	3	0.064	0.005	0.097	n/a
Cadmium	3	0.015	0.002	0.04	n/a
Chromium	3	0.303	0.029	0.77	n/a
Lead	3	0.181	0.002	0.46	n/a
Mercury	3	0.0002	0.0002	0.0002	n/a
Selenium	3	0.002	0.002	0.002	n/a
Silver	3	0.011	0.002	0.02	n/a

n/a = data not available
Source: Radian (1987) as presented in the 1988 Report to Congress

Table 3-11. Low-Volume Combustion Wastes: Coal Pile Runoff EP Toxicity Data (mg/l)

Analyte	Number of Samples	Mean	Minimum	Maximum	Median
Arsenic	3	0.003	0.002	0.006	n/a
Barium	3	0.054	0.04	0.078	n/a
Cadmium	3	0.002	0.001	0.004	n/a
Chromium	3	0.005	0.005	0.005	n/a
Lead	3	0.032	0.002	0.08	n/a
Mercury	3	0.0003	0.0002	0.0003	n/a
Selenium	3	0.002	0.002	0.002	n/a
Silver	3	0.002	0.012	0.0023	n/a

n/a = data not available
Source: Radian (1987) as presented in the 1988 Report to Congress

Table 3-12. Low-Volume Combustion Wastes: Wastewater Brine EP Toxicity Data (mg/l)

Analyte	Number of Samples	Mean	Minimum	Maximum	Median
Arsenic	5	0.194	0.019	0.52	n/a
Barium	5	0.134	0.1	0.18	n/a
Cadmium	5	0.019	0.002	0.04	n/a
Chromium	5	0.148	0.005	0.31	n/a
Lead	5	0.002	0.002	0.002	n/a
Mercury	5	0.005	0.0002	0.025	n/a
Selenium	5	0.314	0.002	1.5	n/a
Silver	5	0.013	0.002	0.03	n/a

n/a = data not available
Source: Radian (1987) as presented in the 1988 Report to Congress

Table 3-13. Low-Volume Combustion Wastes: Mill Reject TCLP Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	12	6	n/a	0.0344	0.0028	0.09	0.03
Barium	12	0	n/a	0.276	0.07	0.56	0.29
Boron	4	1	n/a	0.0623	0.010	0.131	0.054
Cadmium	12	4	n/a	0.0108	0.005	0.20	0.010
Chromium	12	5	n/a	0.0288	0.005	0.09	0.025
Fluorine	4	1	n/a	0.154	0.025	0.29	0.15
Lead	12	5	n/a	0.101	0.005	0.36	0.065
Manganese	4	0	n/a	1.80	0.398	5.13	0.832
Mercury	12	8	n/a	0.0001	0.0001	0.0003	0.0001
Nickel	8	0	n/a	2.47	1.30	3.10	2.72
Selenium	12	3	n/a	0.119	0.0005	0.27	0.135
Silver	12	12	n/a	n/a	n/a	n/a	n/a
Thallium	8	6	n/a	0.128	0.0025	0.030	0.015
Vanadium	4	4	n/a	n/a	n/a	n/a	n/a
Zinc	4	0	n/a	0.0768	0.024	0.099	0.092

Notes: Values below the detection limit were treated as one-half the detection limit.
n/a = data not available
Source: EPRI, 1997

Table 3-14. Low-Volume Combustion Wastes: Mill Reject EP Toxicity Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	12	8	n/a	0.0312	0.0003	0.13	0.0300
Barium	12	1	n/a	0.1526	0.04	0.42	0.087
Boron	4	1	n/a	0.0653	0.010	0.173	0.039
Cadmium	12	7	n/a	0.010	0.0035	0.020	0.0085
Chromium	12	8	n/a	0.0092	0.005	0.020	0.010
Fluorine	4	1	n/a	0.2013	0.025	0.60	0.09
Lead	12	9	n/a	0.0433	0.005	0.12	0.04
Manganese	4	0	n/a	0.6773	0.119	1.36	0.6150
Mercury	12	12	n/a	n/a	n/a	n/a	n/a
Nickel	8	0	n/a	2.5788	0.26	12.4	1.125
Selenium	12	3	n/a	0.0726	0.003	0.20	0.0465
Silver	12	8	n/a	0.01	0.005	0.03	0.005
Thallium	8	6	n/a	0.0181	0.0025	0.080	0.0025
Vanadium	4	4	n/a	n/a	n/a	n/a	n/a
Zinc	4	2	n/a	0.053	0.01	0.10	0.051

Notes: Values below the detection limit were treated as one-half the detection limit.
n/a = data not available
Source: EPRI, 1997

3.2 COMANAGED COAL-FIRED UTILITY WASTES

This section describes the characteristics of leachate from comanaged coal-fired utility wastes. The data presented here are from the same sources described in Section 2.2. These sources provided a limited number of TCLP analyses for wastes comanaged in landfills and surface impoundments. They also provided a number of other analyses that EPA believes are potentially representative of leachate from these wastes. These include data characterizing pore water from within the matrix of wastes comanaged in surface impoundments and water extract data from wastes comanaged in landfills. Table 3-15 presents the TCLP data, Table 3-16 presents the pore water data from surface impoundments, and Table 3-17 presents the landfill extract data.

Table 3-15. Coal-Fired Utility Comanaged Waste: TCLP Data for Comanaged Wastes (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Aluminum	27	0	11	3.69	0.155	11.7	1.86
Antimony	27	12	11	0.00431	0.00105	0.0125	0.0031
Arsenic	27	5	11	0.0382	0.000875	0.236	0.0137
Barium	27	0	11	1.06	0.114	3.63	0.727
Beryllium	27	10	11	0.00151	0.00005	0.00675	0.000847
Boron	27	11	11	3.26	0.103	9.63	2.54
Cadmium	27	7	11	0.00542	0.00015	0.0443	0.001
Calcium	27	0	11	549	44.9	1110	566
Chromium	27	0	11	0.0211	0.00067	0.0589	0.0155
Cobalt	27	7	11	0.00758	0.00192	0.0167	0.00607
Copper	27	3	11	0.0307	0.00105	0.087	0.008
Iron	27	5	11	1.09	0.0058	10.75	0.0876
Lead	27	4	11	0.00365	0.00106	0.00675	0.00353
Magnesium	27	0	11	48.5	2.71	184	33.5
Manganese	27	1	11	0.766	0.0444	2.23	0.192
Mercury	27	20	11	0.00005	0.000005	0.000118	0.00005
Nickel	27	5	11	0.0253	0.0066	0.0508	0.0206
Potassium	27	1	11	5.44	2.33	10.9	4.08
Selenium	27	2	11	0.0686	0.00483	0.440	0.0240
Silver	27	23	11	0.00134	0.0006	0.00225	0.00137
Sodium	27	0	11	1379	1253	1545	1365
Thallium	27	23	11	0.00528	0.00185	0.0152	0.00196
Vanadium	27	1	11	0.0399	0.0054	0.122	0.0245
Zinc	27	0	11	0.192	0.018	1.16	0.094
Sulfate	26	0	11	479	14.0	2025	292

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI Comanagement data

Table 3-16. Coal-Fired Utility Comanaged Wastes: Surface Impoundment Pore Water Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Antimony	11	11	2	Not calculated *			
Arsenic	152	35	14	1.6	0.0075	9.6	0.17
Barium	157	21	14	2.1	0.001	27	0.085
Beryllium	11	10	2	Not calculated *			
Boron	160	9	15	42	0.025	340	11.0
Cadmium	151	110	14	0.034	0.00099	0.25	0.00460
Chromium	155	104	15	0.18	0.00075	0.75	0.049
Cobalt	18	17	3	Not calculated *			
Copper	111	65	13	0.131	0.00085	0.670	0.048
Lead	137	107	12	0.084	0.0008	0.47	0.014
Mercury	4	0	1	0.00080	0.00080	0.00080	0.00080
Nickel	156	68	15	0.70	0.005	8.3	0.10
Selenium	139	46	13	0.21	0.0033	1.03	0.13
Silver	49	49	7	Not calculated *			
Thallium	11	11	2	Not calculated *			
Vanadium	154	34	14	0.24	0.012	0.80	0.13
Zinc	166	106	15	1.7	0.012	2.3	0.096

* The constituent was not detected in any samples or detected in a small number of samples; therefore, meaningful statistical values cannot be calculated.

Notes: Leachate is laboratory extracted pore water. All measurements identified as below detection limit were assigned a value equal to one-half the detection limit. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.

Source: EPRI Comanagement data

Table 3-17. Coal-Fired Utility Comanaged Wastes: Landfill Extract Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	37	17	3	0.0090	0.0059	0.0110	0.010
Barium	37	0	3	0.48	0.14	1.04	0.25
Boron	37	0	3	6.9	0.74	19	1.14
Cadmium	37	37	3	Not calculated *			
Chromium	37	17	3	0.093	0.0041	0.27	0.0069
Copper	37	22	3	0.044	0.005	0.11	0.014
Lead	37	34	3	Not calculated *			
Nickel	37	14	3	0.25	0.043	0.64	0.077
Selenium	37	13	3	0.36	0.36	0.96	0.12
Silver	35	35	3	Not calculated *			
Vanadium	37	3	3	0.15	0.105	0.17	0.16
Zinc	37	23	3	0.063	0.028	0.13	0.036

* The constituent was not detected in any samples or detected in a small number of samples; therefore, meaningful statistical values cannot be calculated.

Notes: Leachate is generated as a 2:1 distilled water to solid extract. All measurements identified as below detection limit were assigned a value equal to one-half the detection limit. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.

Source: EPRI Comanagement data

3.3 OIL COMBUSTION WASTES AS GENERATED

This section presents leachate analyses for oil combustion wastes as generated. That is, it describes fly ash and bottom ash before they are placed in a waste management unit (and possibly mixed together with each other or other combustion wastes). The source of these data is the same as that described in Section 2.3. Tables 3-18 through 3-21 present TCLP and EP toxicity data for constituents of potential concern in oil-fired fly ash and bottom ash. Data also are available from the same source for a small number of samples of washwater solids, composite ash, and other ash at oil-fired facilities. Because of the small number of data points, however, they are not summarized here.

The majority of constituents shown in Tables 3-18 through 3-21 are metals. TCLP and EP leachate data also are available from 25 sites for toxic organics in oil combustion wastes. Of 57 samples, only 6 resulted in analyses above detection limits for one or more organics (one sample for benzene, one for chloroform, one for methyl ethyl ketone, two for chloroform and methyl ethyl ketone, and one for chloroform and 1,2-dichloroethane). Because of the limited number of analyses above detection limits, these organics are not shown in the tables below.

Table 3-18. Fired Combustion Wastes: Fly Ash TCLP Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	24	14	9	0.319	0.01	1.5	0.052
Barium	24	20	9	0.370	0.105	1	0.25
Cadmium	24	7	9	0.160	0.005	0.520	0.085
Chromium	24	11	9	0.447	0.005	1.17	0.297
Lead	24	17	9	0.164	0.03	0.325	0.144
Mercury	24	24	9	0.00108	0.0001	0.0025	0.001
Selenium	24	20	9	0.0622	0.0025	0.183	0.05
Silver	24	20	9	0.0248	0.00052	0.05	0.025
Vanadium	8	0	3	397	36.4	882	273

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

Table 3-19. Oil Combustion Wastes: Fly Ash EP Toxicity Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	11	0	6	0.290	0.001	1.40	0.0765
Barium	11	3	6	0.371	0.025	1.3	0.225
Cadmium	11	2	6	0.0907	0.01	0.28	0.063
Chromium	11	3	6	0.256	0.005	0.867	0.101
Copper	1	0	1	0.23	0.23	0.23	0.23
Lead	11	3	6	0.262	0.005	0.815	0.129
Magnesium	1	0	1	49.4	49.4	49.4	49.4
Mercury	11	6	6	0.00996	0.00025	0.0555	0.00082
Nickel	1	0	1	0.96	0.96	0.96	0.96
Selenium	11	4	6	0.0699	0.0025	0.369	0.0135
Silver	11	5	6	0.0210	0.0002	0.05	0.013
Vanadium	6	0	4	244	10.2	430	268
Zinc	1	0	1	2.35	2.35	2.35	2.35

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

Table 3-20. Oil Combustion Wastes: Bottom Ash TCLP Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	26	9	12	0.391	0.025	3	0.0741
Barium	26	10	12	1.88	0.025	12.9	0.273
Cadmium	26	13	12	0.130	0.00075	0.62	0.0410
Chromium	26	12	12	0.387	0.02	3.44	0.0775
Cyanide	3	2	1	0.264	0.264	0.264	0.264
Lead	26	18	12	1.23	0.012	13.4	0.05
Mercury	26	22	12	0.00133	0.0001	0.00563	0.00095
Nickel	2	0	2	30.7	3.3	58	30.7
Selenium	26	20	12	0.0887	0.0025	0.250	0.0765
Silver	26	20	12	0.0542	0.0002	0.175	0.0318
Vanadium	9	0	3	211	33.2	513	87

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

Table 3-21. Oil Combustion Wastes: Bottom Ash EP Toxicity Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	7	2	6	0.878	0.005	4.15	0.154
Barium	7	1	6	0.379	0.0635	1	0.305
Cadmium	7	2	6	0.0463	0.0025	0.17	0.02
Chromium	7	1	6	0.253	0.005	0.845	0.135
Copper	2	0	2	0.43	0.08	0.78	0.43
Iron	2	0	2	1.50	0.43	2.56	1.50
Lead	7	3	6	0.210	0.005	0.64	0.09
Magnesium	2	0	2	128	48.3	208	128
Mercury	7	6	6	0.00038	0.0001	0.001	0.00025
Nickel	2	0	2	1.41	0.72	2.1	1.41
Selenium	7	4	6	0.025	0.002	0.1	0.00375
Silver	7	4	6	0.0408	0.005	0.15	0.015
Vanadium	3	0	3	185	80.3	244	231

Zinc	2	0	2	1.85	0.4	3.29	1.85

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

3.4 OIL COMBUSTION WASTES AS MANAGED

This section describes the leachate characteristics of oil combustion wastes as managed. Specifically, Tables 3-22 and 3-23 present TCLP and EP toxicity data, respectively, for constituents of potential concern in solids dredged from solids settling basins (SSBs) at oil-fired utilities. The source of these data is the same as that in the previous section.

Table 3-22. Oil Combustion Wastes: Solids Settling Basin Solids TCLP Data (mg/l)

Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	26	14	15	0.0666	0.0015	0.321	0.055
Barium	26	8	15	0.647	0.09	1.7	0.49
Cadmium	26	14	15	0.0187	0.005	0.04	0.0163
Chromium	26	16	15	0.0621	0.005	0.279	0.0438
Lead	26	16	15	0.0824	0.01	0.26	0.0625
Mercury	26	25	15	0.00269	0.0001	0.00781	0.0005
Nickel	3	0	2	28.8	13	44.5	28.8
Selenium	26	14	15	0.0605	0.0025	0.302	0.0538
Silver	26	20	15	0.0353	0.005	0.145	0.01
Vanadium	6	1	4	114	0.01	448	4.9

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

Table 3-23. Oil Combustion Wastes: Solids Settling Basin Solids EP Toxicity Data (mg/l)

Constituent	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Arsenic	51	19	18	0.134	0.00125	0.8	0.0558
Barium	51	11	18	0.286	0.001	0.920	0.275
Cadmium	51	14	18	0.0129	0.001	0.0450	0.00968
Calcium	23	0	8	1048	28.6	4569	328
Chloride	23	0	9	114	11.4	475	29.4
Chromium	58	13	25	0.0635	0.005	0.216	0.05
Copper	25	1	10	0.973	0.02	3.42	0.312
Iron	25	1	10	4.61	0.42	27.4	1.80
Lead	58	15	25	0.163	0.005	0.767	0.1
Magnesium	24	0	8	89.4	6.9	194	79.0
Manganese	9	0	9	1.71	0.14	5.16	1.29
Mercury	51	37	18	0.0306	0.0001	0.5	0.00043
Nickel	32	0	17	11.0	0.26	60	6.5
Selenium	57	25	25	0.0174	0.0025	0.08	0.005
Silver	50	20	18	0.0288	0.0005	0.18	0.0126
Sodium	24	0	9	254	40.5	972	154
Sulfate	29	0	16	374	29	1360	198
Vanadium	34	0	18	49.9	0.55	157.0	41.3
Zinc	33	1	17	2.32	0.02	13.9	1.1

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: EPRI, 1997f

3.5 FLUIDIZED BED COMBUSTION (FBC) WASTES

This section describes the leachate characteristics of FBC wastes. The data used here are from the same source described in Section 2.5. Thirty-five respondents to the CIBO FBC survey, representing 42 percent of the total population of U.S. FBC facilities, provided a total of 240 leachate concentration samples. Thus, the FBC data presented here represent a large number of samples from a substantial fraction of the FBC population. Because the data were not identified as being from as-generated or as-managed samples, they are presented under one heading, rather than two headings as for conventional coal-fired and oil-fired combustion wastes. Tables 3-24 through 3-28 present TCLP and EP toxicity data for FBC fly ash and bed ash, and TCLP data for combined ash. (Because there were very few EP analyses conducted for combined ash, these data are not summarized here).

Table 3-24. FBC Wastes: Fly Ash TCLP Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Aluminum	15	4	5	6.90	0.025	15.8	4.00
Antimony	18	7	6	0.224	0.0095	0.66	0.0375
Arsenic	54	39	13	0.0498	0.0125	0.17	0.03
Barium	61	17	15	3.40	0.0175	42	0.32
Beryllium	8	6	4	0.00947	0.00005	0.025	0.00641
Boron	18	4	8	0.447	0.06	0.76	0.511
Cadmium	52	37	14	0.0193	0.0005	0.09	0.00763
Chromium	54	34	14	0.0577	0.01	0.141	0.0275
Cobalt	5	3	3	0.0725	0.0025	0.19	0.025
Copper	16	4	6	0.042	0.0025	0.077	0.0488
Iron	18	3	7	0.437	0.005	1.14	0.313
Lead	53	39	13	0.113	0.0025	0.505	0.025
Manganese	18	4	7	0.190	0.00125	0.6	0.045
Mercury	53	44	13	0.000661	0.00005	0.00192	0.0005
Molybdenum	15	6	6	0.168	0.11	0.32	0.148
Nickel	43	29	8	0.0926	0.0025	0.3	0.0216
Potassium	6	0	4	24.9	3	44	26.3
Selenium	53	35	13	0.0739	0.002	0.2	0.0514
Silver	52	40	13	0.0258	0.005	0.053	0.025
Thallium	5	5	2	0.0229	0.0208	0.025	0.0229
Vanadium	29	3	2	0.105	0.025	0.185	0.105
Zinc	19	3	8	0.111	0.0025	0.35	0.0687

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 3-25. FBC Wastes: Fly Ash EP Toxicity Data (mg/l)							
Analyte	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Aluminum	5	0	2	19.7	15.1	24.27	19.7
Antimony	5	0	2	0.583	0.018	1.15	0.583
Arsenic	9	3	4	0.154	0.00125	0.6	0.00717
Barium	9	1	4	0.573	0.5	0.713	0.539
Boron	3	0	2	0.728	0.475	0.98	0.728
Cadmium	9	2	4	0.0259	0.0005	0.0442	0.0295
Chromium	9	1	4	0.174	0.0125	0.455	0.114
Copper	3	0	2	0.0965	0.093	0.1	0.0965
Iron	5	0	2	0.365	0.237	0.493	0.365
Lead	9	2	4	0.227	0.0025	0.393	0.257
Manganese	5	0	2	0.637	0.625	0.648	0.637
Mercury	6	3	4	0.0729	0.00005	0.29	0.00082
Molybdenum	4	0	2	0.512	0.49	0.533	0.512
Nickel	5	0	2	0.141	0.115	0.168	0.141
Selenium	7	2	4	0.065	0.0025	0.235	0.0112
Silver	7	2	4	0.028	0.02	0.035	0.0285
Zinc	5	0	2	0.792	0.138	1.45	0.792

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 3-26. FBC Wastes: Bed Ash TCLP Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Aluminum	11	4	3	1.36	0.164	2	1.91
Antimony	12	4	4	0.218	0.025	0.52	0.163
Arsenic	47	33	10	0.0369	0.0025	0.125	0.0301
Barium	48	23	10	0.613	0.025	2.5	0.245
Beryllium	4	4	3	0.01085	0.00005	0.025	0.0075
Boron	12	6	4	1.328	0.13	2.6	1.29
Cadmium	44	35	9	0.0175	0.0005	0.051	0.0216
Chromium	47	38	10	0.0526	0.0025	0.14	0.025
Cobalt	3	1	2	0.125	0.025	0.225	0.125
Copper	12	3	3	0.0403	0.0275	0.0633	0.03
Iron	13	0	4	2.03	0.16	4.5	1.73
Lead	46	36	9	0.0715	0.0025	0.235	0.0168
Manganese	13	0	4	0.403	0.05	1.27	0.145
Mercury	46	41	9	0.00116	0.00025	0.005	0.0005
Molybdenum	9	5	2	0.16	0.119	0.2	0.16
Nickel	37	26	4	0.119	0.0167	0.28	0.0888
Potassium	2	0	2	6.5	2	11	6.5
Selenium	45	42	9	0.0415	0.002	0.158	0.025
Silver	45	40	9	0.0533	0.005	0.25	0.025
Thallium	3	2	2	0.0356	0.025	0.0463	0.0356
Vanadium	27	4	2	0.941	0.025	1.858	0.941
Zinc	14	2	5	0.141	0.015	0.51	0.0738

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 3-27. FBC Wastes: Bed Ash EP Toxicity Data (mg/l)							
Analyte	**Number of Samples**	**Number of Non-Detects**	**Number of Sites**	**Mean**	**Minimum**	**Maximum**	**Median**
Aluminum	3	0	2	14.3	13.1	15.6	14.3
Antimony	3	0	2	0.4335	0.425	0.44	0.433
Arsenic	8	3	4	0.00871	0.00217	0.0167	0.008
Barium	6	1	4	0.552	0.15	0.85	0.603
Beryllium	1	0	1	0.28	0.28	0.28	0.28
Boron	1	0	1	0.55	0.55	0.55	0.55
Cadmium	7	2	4	0.02	0.0005	0.035	0.0223
Chromium	7	2	4	0.103	0.0125	0.27	0.0646
Copper	3	0	2	0.0765	0.053	0.1	0.0765
Iron	4	0	2	0.528	0.465	0.59	0.528
Lead	8	2	4	0.18	0.0025	0.258	0.23
Manganese	3	0	2	0.429	0.355	0.503	0.429
Mercury	5	3	3	0.000664	0.00005	0.00125	0.000692
Molybdenum	2	0	2	0.385	0.16	0.61	0.385
Nickel	3	0	2	0.109	0.102	0.115	0.109
Selenium	6	3	4	0.00498	0.00242	0.01	0.00375
Silver	7	1	4	0.0245	0.018	0.04	0.02
Zinc	5	0	2	0.748	0.111	1.39	0.748

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

Table 3-28. FBC Wastes: Combined Ash TCLP Data (mg/l)							
Analyte	Number of Samples	Number of Non-Detects	Number of Sites	Mean	Minimum	Maximum	Median
Aluminum	23	2	8	3.27	0.28	9.44	2.76
Antimony	21	15	8	0.121	0.00065	0.27	0.0808
Arsenic	32	9	12	0.102	0.0023	0.365	0.0398
Barium	33	10	12	1.22	0.0223	10.5	0.292
Boron	23	6	9	3.2	0.0367	26.7	0.347
Cadmium	30	22	11	0.0181	0.00125	0.096	0.00563
Chromium	33	16	12	0.0667	0.0033	0.25	0.0311
Cobalt	8	4	4	0.106	0.0065	0.4	0.00845
Copper	26	13	10	0.0574	0.00188	0.203	0.0469
Iron	23	8	9	0.23	0.0025	1.09	0.115
Lead	30	22	12	0.13	0.001	1	0.0533
Manganese	25	5	9	0.208	0.00208	0.507	0.157
Mercury	30	23	11	0.00198	0.00005	0.0169	0.0002
Molybdenum	22	8	9	0.108	0.0125	0.21	0.085
Nickel	25	12	10	0.121	0.0025	0.46	0.0689
Potassium	7	0	3	10.9	1.55	18.5	12.5
Selenium	33	16	12	0.0584	0.00413	0.175	0.0378
Silver	31	21	12	0.0253	0.0038	0.145	0.01
Zinc	24	8	10	0.114	0.0025	0.38	0.074

Notes: All measurements identified as below detection limit were assigned a value equal to one-half the detection limit for use in the calculations. All concentrations are facility-averaged; i.e., multiple measurements from a single site are averaged, and the resulting population of facility averages used to generate the statistics in this table.
Source: CIBO, 1997

4.0 REFERENCES

Arthur D. Little. 1985. *Full-Scale Evaluation of Waste Disposal from Coal-fired Electric Generation Plants.* Prepared for U.S. EPA. EPA-600-7-85-028. June.

CIBO (Council of Industrial Boiler Owners). 1997. Responses to Fossil Fuel Fluidized Bed Combustion By-Products Survey. November.

Envirosphere. 1981. Information Responding to EPA's Request Regarding Burning and Co-Treatment/ Co-Disposal of Low Volume Wastes Generated at Fossil Fuel Fired Electric Generating Stations. Prepared for Utility Solid Waste Activities Group and Edison Electric Institute. August.

EPA (U.S. Environmental Protection Agency). 1988. *Report to Congress: Wastes from the Combustion of Coal by Electric Utility Power Plants*. EPA/530-SW-88-002. February.

EPRI (Electric Power Research Institute). 1991. *Comanagement of Coal Combustion By-Products and Low-Volume Wastes: A Southeastern Site*. Final Report. EN-7545. November.

EPRI. 1992. *Comanagement of Coal Combustion By-Products and Low-Volume Wastes: A Midwestern Site*. Interim Report. TR-100955. August.

EPRI. 1994a. *Calcium-Based Flue Gas Desulfurization Sludge Disposal Sites*. Final Report, TR-103914. April.

EPRI. 1994b. *Sodium-Based Flue Gas Desulfurization Sludge Disposal Ponds*. Final Report, TR-103915. April.

EPRI. 1996a. *Comanagement of Coal Combustion By-Products and Low-Volume Wastes: A Southwestern Site*. Final Report. TR-105673. June.

EPRI. 1996b. *Evaluation of the Co-Management of High Volume Combustion By-Products with Other Utility Wastes: CL Site*. Draft Report. May (updated December).

EPRI. 1997a. *Evaluation of the Co-Management of High Volume Combustion By-Products with Other Utility Wastes: MO Plant*. Draft Report. April.

EPRI. 1997b. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Combustion By-Products: AP Site*. Draft Report. June.

EPRI. 1997c. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Combustion By-Products: SX Site*. Draft Report. TR001015. June.

EPRI. 1997d. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: P4 Site*. Final Report. TR 108420. July.

EPRI. 1997e. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: OK Site*. Draft Report. TR 108421. July.

EPRI. 1997f. Oil Combustion By-Products Database. July.

EPRI. 1997g. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: HA Site*. Draft Report. August.

EPRI. 1997h. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: FC Site*. Draft Report. TR 108425. August.

EPRI. 1997i. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: LS Site*. Final Report. TR 108422. August.

EPRI. 1997j. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: PA Site*. Final Report. TR 108427. August.

EPRI. 1997k. *Field Evaluation of the Comanagement of Utility Low-Volume Wastes with High-Volume Coal Combustion By-Products: CY Site*. Final Report. TR 108426. August.

EPRI. 1997l. *Characterization and Management of Mill Rejects at Electric Power Plants*. Draft Report. August.

EPRI. 1998. *PCDDs and PCDFs in Coal Combustion By-Products (CCBS)*. Final Report. March.

Radian. 1985. *Characterization of Utility Low-Volume Wastes*. Prepared for EPRI. May.

Radian. 1987. *Manual for Management of Low-Volume Wastes from Fossil-Fuel-Fired Power Plants*. Prepared for EPRI. July.

Tetra Tech. 1983. *Physical-Chemical Characteristics of Utility Solid Wastes*. EPRI EA-3236. September.